A time-resolved particle-image velocimetry study on the unsteady flow behaviour of leading-edge tubercled hydrofoils

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Keywords: Hydrofoil, Tubercle, Unsteady flow, Time-resolved PIV

HIGHLIGHTS
• A baseline and a leading-edge tubercled hydrofoil were studied using time-resolved particle-image velocimetry technique
• The experiments were conducted in a water tunnel using a continuous-wave diode-pumped solid state laser and a high-speed CCD camera
• Streamwise flow separation behavior and region size fluctuate significantly along trough-plane of tubercled hydrofoil
• Interactions between streamwise vortices produced by leading-edge tubercles interact become increasingly significant further downstream from the leading-edge
• Streamwise vortices are displaced further away from the hydrofoil surface with their displacements demonstrating some regularity

ABSTRACT
A time-resolved particle-image velocimetry study has been conducted to look into the flow separation behavior associated with leading-edge tubercled hydrofoils and how its unsteadiness could be related to the behavior of the streamwise vortices produced by the leading-edge tubercles. Streamwise measurement results taken at 15° angle-of-attack show that the baseline hydrofoil produce relatively consistent flow separation behavior and region size from the leading-edge, as expected. While similar observations can be made along the trough-plane of the leading-edge tubercled hydrofoil as well, flow separation behavior and region size those along the peak-plane was observed to fluctuate temporally. Cross-stream measurement results taken at different locations along the leading-edge tubercled hydrofoil surface reveal that such an observation may be attributed to the behavior of the streamwise vortices as they developed progressively downstream along the hydrofoil surface. Results demonstrate that interactions between adjacent streamwise vortices become increasingly more significant further along the hydrofoil surface, with the streamwise vortices being displaced increasingly further away from the hydrofoil surface. As such, these preceding behaviours might have caused variations in the flow separation behavior and region size along the peak-plane of the leading-edge tubercled hydrofoil observed earlier.

Fig. 1 (a) Leading-edge tubercled hydrofoil and the cross-stream vorticity maps associated with streamwise vortices at (b) quarter-chord location and (c) 20mm downstream of quarter-chord location